23. Particles 1: trajectories

Friday, November 8, 2024 3:55 PM

Admin: YES CLICKERS and SLACK TODAY

Today:
Particles:
Interaction with flow

II Particles

Heavy seeding

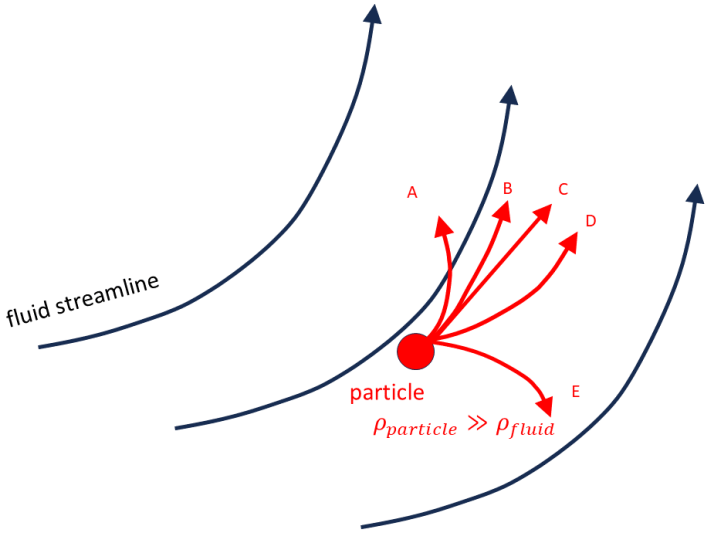
Number density high enough to look like a dye
Similar considerations to dyes:
1)Particles must track with the flow Big difference from dyes
Dyes are molecules, track with the flow just fine.

2)Want particles to NOT disturb flow
3)Want particles to show up - HIGH VISIBILITY

1) When will particles track well, be good tracers?

Clicker: Consider a curved streamline in a **horizontal plane.** Consider a small particle, much denser than the fluid. We are looking down on the trajectories; don't worry about gravity; it will just cause a slow drift out of the plane

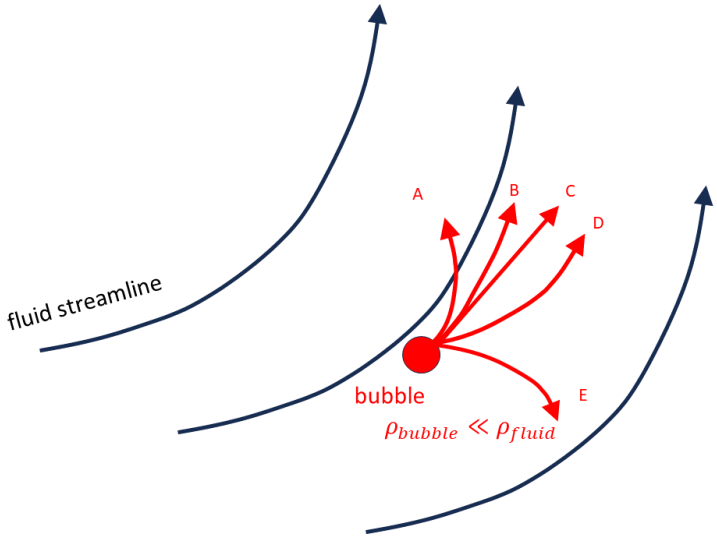
What will the particle path look like compared to the fluid path?



A: into the curve
B: along the streamline
C: tangent to the streamline
D: outside the streamline
E: opposite to the curve

	2024	2023
A	0	6%
B	15	44
C	31	44
D	54	6
E	0	0

Next, consider same scenario, but a bubble instead of a particle.



A: into the curve
B: along the streamline
C: tangent to the streamline
D: outside the streamline
E: opposite to the curve

	2024	2023
A	31	50%
B	54	50
C	0	0
D	8	0
E	8	0

Ever been hit in the back of the head by a balloon when you are accelerating in a car?
http://www.youtube.com/watch?v=XXpURFYgR2E

For particles (or bubbles) to track with the surrounding fluid, they must accelerate the same as the neighboring fluid

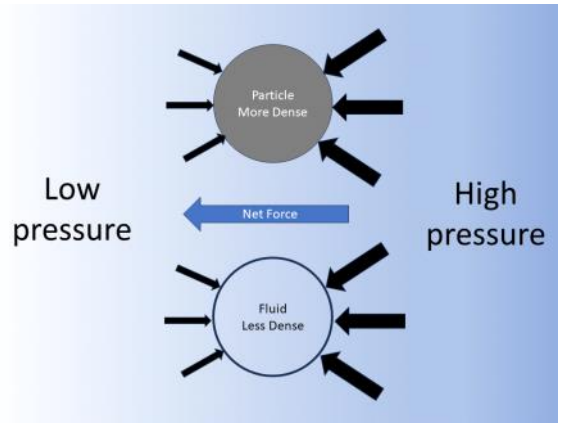
What are the forces **on particle**?

Body: gravity, neglect.

Surface:	normal = pressure parallel = shear

from fluid

First, **assume** a pressure gradient acting on a spherical particle and fluid blob, same size:



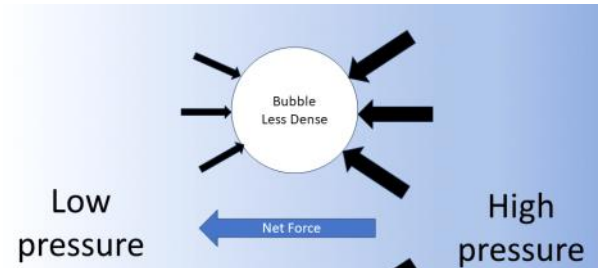
A) The net forces on the particle and fluid are the same
B) The net force on the particle is greater than on the fluid
C) The net force on the fluid is greater than on the particle

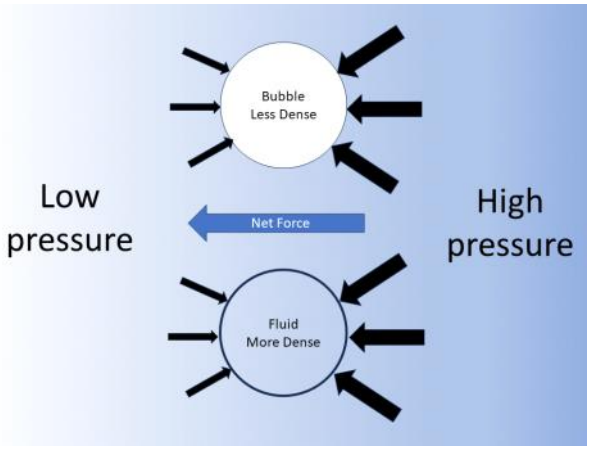
	2024
A	67%
B	33
C	0

Which particle will accelerate more in this pressure gradient?
A) They will accelerate the same
B) The particle will accelerate more
C) The fluid will accelerate more

	2024
A	7%
B	14
C	79

NSL
$F = ma$





A) The net forces on the bubble and fluid are the same
B) The net force on the bubble is greater than on the fluid
C) The net force on the fluid is greater than on the bubble

	2024
A	92%
B	0
C	8

Which will accelerate more in this pressure gradient?
A) They will accelerate the same
B) The bubble will accelerate more
C) The fluid will accelerate more

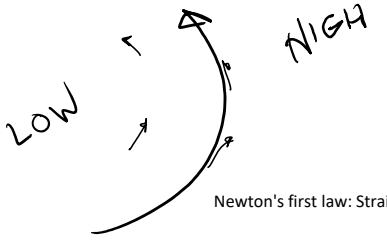
	2024
A	0%
B	100
C	0

Why???? Because Newton's Second Law: $\sum F = ma$

NSL: $F = ma$

What makes streamlines curve?

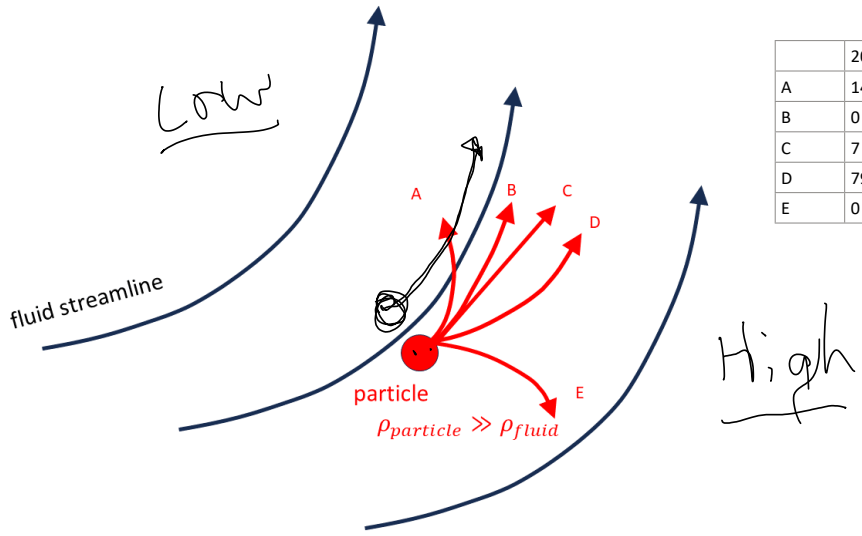
(what is a streamline?)



Newton's first law: Straight path unless *forced* to curve.

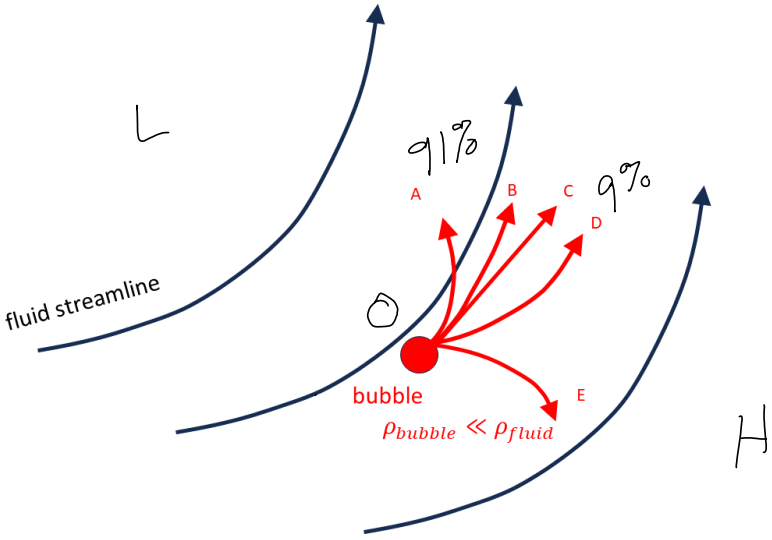
Streamlines curve because of pressure gradient. Low P is inside curve.

Now, put these ideas together. Relative forces, relative accelerations



	2024
A	14
B	0
C	7
D	79
E	0

Next, consider same scenario, but a bubble instead of a particle.



	2024
A	91
B	0
C	0
D	9
E	0

Summary

- Lighter particles will track to inside the curve
- Denser particles will track to outside the curve

Rules of thumb:

- In water or other liquids, particles of 100 µm diameter or less, any density, will track most flows.
- In air, particles of 1 µm diameter or less, any density, will track most flows.

Similar considerations to dyes:
1) Particles must track with the flow
2) Want particles to NOT disturb flow
3)Want particles to show up - HIGH VISIBILITY

2)Want particles to NOT disturb flow

- As with dyes, minimize injection differential velocity; inject at local flow speed.
- Want particles to not introduce new forces or effects. Avoid:
  - soluble particles
  - surface tension: Cheerio effect
  - The Cheerios Effect

- chemical reactions
- significant change of density
- particle-particle interaction

Heavy Seeding

- Number density of particles = # of particles / unit volume. (Contrast to mass/volume of solid alone). Keep low enough to avoid interactions.
- Particle-particle interaction (collisions, drag) lead to non-Newtonian effects. Slurries, oobleck, blood, shampoo, silly putty, other polymers. Gets into 'complex fluid' categories. Interesting field.